THE PUBLIC MORTUARY, 200 TOWNMEAD ROAD, LONDON, SW6 2RE

BUSINESS CASE FOR REPLACEMENT OF THE MORTUARY HVAC SYSTEMS

Summary

The Public Mortuary mechanical services installation has been updated over the years to arrive at the present situation. The current mechanical services plant needs replacement and as such the option to reduce GHG (Green House Gases) emissions in line with LBHF (London Borough of Hammersmith & Fulham) own targets can be considered.

The existing Air-Cooled chiller is at the end of its economic life cycle. It is proposed that the existing Air-Cooled Chiller and gas fired boilers are replaced with an Air Source Heat Pump(s) (ASHP). This action will provide for a reduction in GHG emissions and some reduction in energy costs.

Currently, the annually energy consumption and costs of the existing installed system is 194,097 kWh annually and £29,565.81p respectively. The CO2 emissions is 24,000kg annually.

The annually energy consumption and costs of the proposed system is 88,524 kWh annually and £27,630.39p respectively. The CO2 emissions is 10,946kg annually.

As can be seen from the above, there is an increase in the electrical usage when the proposed system is installed as this includes the Air Source Heat Pump which is powered by electricity. The electricity costs increases from £19,422.81p to £27,630.39p annually. The gas costs decreases from £10,143.00 to £465.45p as the boilers are only used when there are extreme low temperatures, i.e., below 0^{o}C. The CO2 emissions decreases from 24,000 kg to 10,946 kg annually.

The proposed installation will provide approximate annual cost savings of £1,935.42p with a 55% reduction of 13,054 kg of CO2 annually.

It can be seen that the proposed air source heat pump system will provide a small reduction in the annual energy cost, and a much larger 55% reduction in CO2 emissions annually.

The estimated replacement costs for the existing Air-Cooled Chiller with an Air Source Heat Pump and associated Air Handling Units, Hot Water Cylinders and upgraded controls is £710,000.

Introduction

A review of the Public Mortuary Mechanical Installation has been undertaken with a view to the Governments Climate targets and GHG emissions and LBHF own targets in helping to achieving net zero by 2030.

The Public Mortuary Serves the LBHF and surrounding areas.

This report provides a description of services installed, system details, and a view to their condition and reinstatement to minimise any downtime due to failure of plant or equipment.

Some parts of the building services were installed in 2007 and upgraded again in 2010. It is believed that the original installation dates from 1990.

A visual non-intrusive inspection was made in January / February 2023.

A full PPM regime is in force and all relevant water treatment, fire alarm and emergency lighting test certificates are available.

The purpose of this report is to provide information as it relates to the replacement of the existing chiller and gas fired boilers with an Air Source Heat Pump (ASHP) that provides both low pressure hot water and Chilled Water in maintaining the comfort conditions within the building. This will also reduce the building running costs by reducing the energy used and hence greenhouse gas emissions (GHG).

The existing installation has reached the end of its life cycle. Various items of plant over recent times have required replacement parts. The frequency of breakdowns keeps increasing. The users have complained of conditions that do not meet comfort conditions as required.

Net zero means that the UK's total greenhouse gas (GHG) emissions would be equal to or less than the emissions the UK removed from the environment. This can be achieved by a combination of emission reduction and emission removal.

Most UK heating used natural gas in 2015. To meet binding EU renewables targets for 2030 the UK will likely need to deploy more low carbon heating. Significant deployment will be needed by 2030 to meet UK greenhouse gas emissions targets. The carbon footprint of electrical or hydrogen heating and heat networks can be lower than fossil-fuelled heating, but only if the footprint of the energy source is low. Biomass boilers and bio-sourced gas usually have a low footprint. For industrial heating, carbon capture and storage, offers a key low footprint option. The success of heat policy will also depend on consumer preferences, technological constraints, and energy efficiency. These make the widespread decarbonisation of heating a major challenge.

Gas fired heating is used for domestic, commercial, and industrial purposes and accounts for around a third of UK greenhouse gas (GHG) emissions. Other large emissions sources include power generation, transport, industrial processes, and agriculture. Around 50% of heat emissions come from the domestic sector, 20% from the commercial sector and 30% from the industrial sector. In the UK domestic and commercial setting, 98% of GHG emissions from heat come from space and water heating, with 2% from cooking. In the industrial sector, only 13% come from space and water heating; the rest are from specialised industrial processes.

The Government is aiming to reduce GHG emissions from heat and increase the proportion of heat from renewable sources from 2% in 2014 to 12% by 2020 to help the UK meet binding targets. However, progress on the decarbonisation of heating has been criticised as too slow. Following this criticism, the Energy and Climate Change Committee has started an inquiry on progress towards the 2020 renewable heat targets.

The continued switch away from coal towards gas and renewable energy by the energy supply industry has resulted in a general reduction in GHG emissions since 1990. Reaching net zero would require continuing to reduce emissions from this industry, households and from other industries, in particular those with the highest associated emissions such as transport, manufacturing and agriculture[2].

GHG emissions can be removed by the natural environment or by using technologies like carbon capture (usage) and storage (CC(U)S).

The Committee on Climate Change estimate that in 2050 it is likely that somewhere between 75 to 175 million tonnes of carbon dioxide equivalent will need to be removed by carbon capture (usage) and storage (CC(U)S) annually in order to meet net zero, given it is unlikely that all sources of GHG emissions can be eliminated.

Heat pumps

Heat pumps have a number of different forms and exploit different sources of low-grade heat. Worldwide, the heat pumps most widely used for heating are reversible air-to-air (air source heat pumps) units that can also be used for cooling. Such units are typically found where there is significant need for cooling and the need for heating is limited. In the UK climate, electrically driven air source heat pumps are not frequently installed solely to provide heating, which may be explained by the relatively high price of electricity in relation to gas. Ground Source Heat pumps offer a particularly attractive option for heating when there is a suitably large source of low-grade heat, such as a river, canal, or an area of ground. Gas-fired ground source heat pumps currently being evaluated for use in housing as a boiler replacement are reported to have a seasonal efficiency (coefficient of performance) of around 1.4.

Energy storage

Energy storage may either be used to reduce peak loads or to take advantage of lower energy prices at certain times of day. Heat is stored using either solid cores or hot water vessels. The most common application of thermal storage is in dwellings, in which solid core storage is charged with heat at off-peak rates for a 7- or 8-hour period. Guidance for the design of such systems is contained in Electricity Association publication Design of mixed storage heater/direct systems. Systems relying on hot water storage vessels are also available for use in dwellings.

The three main types are as follows: —

1. Combined primary storage units (CPSU): provide both space and water heating from within a single appliance, in which a burner heats a thermal store. The water in the thermal store is circulated to radiators to provide space heating, while a heat exchanger is used to transfer heat to incoming cold water at mains pressure to provide a supply of domestic hot water.
2. Integrated thermal stores: also provide both space and water heating from within a single appliance. However, they differ from CPSUs in that a separate boiler is used to heat the primary water.
3. Hot-water-only thermal stores: use thermal storage only for production of domestic hot water. As for the two types described above, the domestic hot water is provided by a heat exchanger working at mains pressure. Also, some models of combination boiler contain a small thermal store to overcome the limitation on flow rates for domestic hot water. Thermal storage for larger buildings must rely on purpose-designed storage vessels with capacity and storage temperature optimised for the heat load.

Other design parameters that must be considered are insulation of the storage vessel, arrangements for dealing with expansion and the control strategy for coupling the store to the rest of the system.

Domestic hot water

Whether or not to produce domestic hot water from the same system as space heating is a key decision to be taken before detailed design proceeds. In housing, where demand for hot water is a substantial proportion of the total heat load, a hydronic heating system is usually the most convenient and satisfactory means of producing hot water, using either a hot water storage cylinder or a combination boiler. In buildings other than housing, the case for deriving domestic hot water from a hydronic heating system depends greatly on circumstances. The demand for hot water and the locations with the building where it is required will affect the relative costs of independent heat generation and connection to the space heating system. In general, independent hot water generation is the more economical choice when relatively small amounts of hot water are required at positions distant from the boiler. Circulating hot water circuits that require long pipe runs and operate for extended periods solely to provide hot water can waste large amounts of energy, particularly during summer months when no space heating is required. In commercial buildings, toilet areas are often best served by independent gas or electric water heaters.

Description of Existing Mechanical System

Low Pressure Hot Water Heating System

The Mortuary currently has 2 existing condensing boilers providing heat to the whole building and the AHU LPHW heating Coils. The boilers currently serving the building are manufactured by Hamworthy Heating Limited. The model is Stratton STW100, nominal output 100 kW (Condensing).

The boiler house is located in an adjoining dedicated Building which also contains the back-up Generator and the incoming electrical supply. The boiler installation is approximately 5 years old, but the other parts of the installation is in excess of 15 years old. This building is heated by a gas fired low pressure hot water (LPHW) system; this consist of 2 Hamworthy Stratton STW 100 boilers of approximately 100 kW (condensing) each. The flue rises above the roof and terminate with a cowl to discharge the diluted products of combustion. Air is drawn in from the adjacent louvred door of the boiler house.

The distribution circuit supplies the heating coils of the AHUs and the radiators within the building. Duplicate pump sets (duty and standby) are installed within the plant room which serves the radiators and the AHU LPHW heating coils.

The system has been designed as a closed, pressurised system with an automatic fill/pressurisation unit to maintain a pressurised make up cold fill and accommodate thermal expansion. A packaged pressurisation unit and expansion vessels for the Primary and Secondary heating circuits are accommodated in the plant room.

A facility for introducing water treatment chemicals into the system and for drawing off system water for sampling is provided by a side stream dosing pot connected across the primary ring circuit flow and return and another across the secondary flow and return circuit.

Domestic Hot Water System

The hot water is generated by a 2 No gas fired Andrews Water Heaters, Model CSC78 GB, 276 litre storage. These hot water generators are installed in the roof plant room above the Mortuary.

A cold-water main enters the roof plant room from below to serve the GRP sectional cold-water storage tanks located in the roof plant room and also serves the 2 No gas fired Andrews Water Heaters.

The 2 No gas fired Andrews Water Heaters will be replaced with Hot Water Calorifiers that will make use of the hot water generated by the ASHP.

Domestic Cold-Water System

2 No Pre-insulated cold-water storage tanks are located in the roof above the Mortuary in a dedicated area which also includes the AHU's serving the Mortuary. It These can be retained for the foreseeable future and does not need to be considered for immediate replacement.

Air Conditioning

The building is comfort air conditioned by 3 No Air Handling Units serving the Postmortem Room, Changing Rooms, Foul Postmortem Room, and the remaining areas are served by high level wall mounted split units.

Ventilation

Fresh air is provided by means of air handling units installed in the dedicated first floor plant room. Vitiated air is extracted from the space via low level grilles / diffusers and ductworks and discharged at roof level externally.

Chilled Water System

The Mortuary is served by 3 No AHUs providing supply and extract air which passes through a number of processes to provide the correct comfort conditions within the space. Separate extract fans extract the vitiated air from the space and discharges it to the outside. The supply air is filtered by HEPA filters providing the highest filtration required. The AHUs are fitted with LPHW pre-heating and after-heating coils as well as Chilled Water-Cooling Coils, supply, and extract fans.

3 - DX-split systems provide comfort conditions to some rooms. Conditioned air is supplied by ductwork connected to square or linear ceiling mounted diffusers. Vitiated air is extracted from the space via low level linear diffusers connected by means of circular hard and flexible ductwork.

Wall mounted temperature sensors schedule either heated or cooled air to the space according to requirements.

Chilled water for air conditioning system air cooling is generated by a packaged air-cooled unit, model reference, AquaSnap 30RBS-140-0052-PEE, as manufactured and supplied by Carrier (UK) Ltd and is circulated to the cooling coils on the AHUs through a flow and return distribution pipework system.

The chilled water provides chilled water circulation at a flow and return temperature of 7/12 ^{o}C respectively to the AHUs' cooling coils.

The complete system has been designed as a closed, pressurised system and uses an automatic fill/pressurization unit to maintain pressurised make-up cold fill and accommodate operational variations in system pressure.

A facility for introducing water treatment chemicals into the system and for drawing off system water for sampling is provided by a side stream dosing pot connected across the primary flow and return circuit.

The chiller unit is a packaged air-cooled chilled water unit suitable for outdoor mounting and incorporating encased reciprocating compressors, a twin circuit shell and tube evaporator and a multi-pass air-cooled condenser fitted with 2 x cooling fans and built-in pumps and controls. A pre-wired control panel supplied with the unit houses all the necessary safety devices and controls.

The air-cooled chilled water plant utilizes refrigerant R134a. The chilled water plant is approximately 12 years old.

System circulating pumps are of the direct driven end-suction centrifugal type and are connected into the system through a primary /secondary chilled water header mounted in the boiler room. The pumps are mounted on sprung inertia antivibration bases. Each pump is fitted with suction and delivery isolating valves, a delivery non return valve, a suction strainer and suction and delivery pressure gauges. The pump set is arranged for automatic duty/standby changeover if the selected duty pump of the set fails.

The pressurization unit is packaged unit as Mikrofill 3 pressurisation unit connected to a separately mounted diaphragm expansion vessel and all necessary prewired controls for fully automatic operation.

The unit is installed in the boiler room and is connected to the circuit return through a cold fill/expansion line.

A quick fill connection is tapped off the primary circuit within the boiler room for refilling the supply direct from the mains water supply following a complete drain down.

All exposed system pipework is insulated and is also protected against frost damage by electric trace heating.

The control panels appear to be in reasonable condition and currently provides fully automatic control for the systems. One monitoring control panel located in the reception of the building is fitted with a trend IQ4 outstation. The main control panel is located in the roof level plantroom, but the lamps do not appear to be functioning. This will require upgrading if it is to be re-used to provide overall monitoring, alarm status, set points, time switches, logging and plant status.

Description of Proposed Replacement Air Source Heat Pump System

The Air Source Heat Pump / Multi Pipe Unit shall be as manufactured and supplied by Trane Equipment Ltd or Equal and approved, model reference CMAF040 HE EC XLN R454b - 2 No. The Air Source Heat Pump shall be coupled with a Cascade system (model reference LIFT202P – 2 No) to ensure that a minimum temperature of 90^{o}C is supplied to the heating side of the system.

Air Source Heat Pump Unit Overview

141.28 kW –109.50 kW heating and cooling capacity.

Gross total absorbed power -42.8 kW (cooling)

Gross total absorbed power -43.75 kW (Heating)

R134a version with AC fans or optional EC fans for higher efficiency.

R513A version with EC fans.

Optional inverter driven compressors.

Class A in full load efficiency cooling and heating.

Eco-design Compliant (ErP2021)

Hot water up to 55 ^{o}C

Partial heat recovery option.

Heat pump operation down to -10 ^{o}C ambient.

Finn & Tubes outdoor heat exchanger.

Falling film evaporator.

Optional compressor sound attenuation enclosure.

Duplex version available up to 1500 kW.

Trane controls with easy-to-use Tracer TD7 touch screen user interface.

Unit power supply – 400V / 50 Hz / 3Ph

Outdoor air-dry bulb temperature – 35 ^{o}C (Cooling).

Water side heat exchanger minimum flow – 3.40 l/s (cooling)

Water side heat exchanger minimum flow – 2.10 l/s (heating)
Water side heat exchanger minimum flow – 10.10 l/s (cooling)
Water side heat exchanger maximum flow – 7.90 l/s (heating)

The cascade system is made up of two stages.
Outdoor air-dry bulb temperature – -4 ^{o}C Heating).
Relative Humidity – 90%.
Fluid Entering Temperature - 12^{o}C (Cooling).
Fluid Entering Temperature – 40 ^{o}C (Heating)
Fluid leaving Temperature - 7^{o}C (Cooling).
Fluid leaving Temperature – 45 ^{o}C (Heating)
Fluid type and concentration – Water
Outdoor air-dry bulb temperature – 35 ^{o}C (Cooling).
Outdoor air-dry bulb temperature – -4 ^{o}C (Heating).
Maximum starting current – 66.28 Amps.
Maximum power at maximum – 103.68 kW
Displacement power factor – 0.870
Length x Width x Height (mm) – 2500 x 1993 x 2410

The first stage consists of air source heat pump producing hot water at a moderate temperature of 25 ^{o}C - 30 ^{o}C. The second stage consists of water source heat pumps, also called boosters, capable of producing water at higher temperatures up to 120 ^{o}C.

The air source heat pump uses R454B with the lowest Global Warming Potential (GWP) value with the option of replacing R410A.

Energy Consumption of Existing Installed system

Electricity usage – 58,857 kWh annually or £19,422.81p
Gas Usage – 135,240 kWh annually or £10,143.00p
Annual Energy Costs (Gas + Electricity) - £29,565.81p
CO2 emission – 2000 kg/month or 24000 kg/year

Energy Consumption of Proposed Installed System

Electricity usage – 82,318 kWh annually or £27,164.94p

Gas Usage – 6206 kWh annually or £465.45p

Annual Energy Costs (Gas + Electricity) - £27,630.39p

CO_2 consumption – 912 kg/month or 10,946 kg/year.

Please note that the gas usage in the above, in this instance, is only recorded to show that if the existing boilers are retained as a backup for the air source heat pumps, especially during periods when the outdoor temperature drops below 3 ^oC, the outdoor design temperature for London. At temperatures of 3 ^oC and below, the heat content of the outdoor air is minimal. The heat that is available to the air source heat pumps from the outdoor air will require the use of boosters used with the heat pumps to boost the required design hot water temperature will increase the electrical usage of the plant. With the use of the boilers, there will be a reduction in electricity usage by the air source heat pump.

Budget Estimate of Cost to Supply and Install New Heat Pumps and Other Equipment.

Supply, install and commission Air Heat Pumps - £400,000

Supply and install 3 No Duplicate circulating pump sets - £30,000.

Supply, install and commission side stream filter on LPHW secondary circuit – £10,000.

Supply, install and commission side stream filter on CHW secondary circuit – £10,000.

Supply, install and commission HWS Calorifiers complete with electric immersion heaters and destratification pumps – 2 No - £20,000

Supply, install thermal insulation to all LPHW pipework - £5,000.

Supply, install thermal insulation to all CHW pipework - £5,000.

Supply, install thermal insulation to all CWS pipework - £5,000.

Supply, install thermal insulation to all HWS pipework - £5,000.

Supply, install and commission Air Handling Units - £120,000.

Supply and Extract Ductwork modification to AHU - £10,000.
Pipework modification to suit AHUs - £10,000.
Supply, install and commission new mechanical controls and modify existing control panel to meet new equipment and plant - £30,000.
Testing, commissioning, and setting to work and users' demonstration - £5,000.
O & M Manuals and as installed drawings – £6,000.
Miscellaneous - £35,000
Total Budget Costs, say – £710,000.

Wider considerations for heat policy

The carbon footprint is far from the only factor to be considered in finding the 'best' way to decarbonise heating. The way heat is decarbonised, the choice of heating option and the speed that consumers move to new technologies will also depend on a wider range of important factors.

Consumer Preference

A range of consumer preferences may inhibit the adoption of alternative technologies.
Most consumers seek the cheapest heating option, which for most is a boiler. Government policies have made some lower carbon options cost competitive if lower running costs are taken into account. However, the upfront costs of some of these technologies are several thousand pounds more than a gas boiler. The costs of many newer technologies are expected to fall as supply chains improve.

Heat pumps, solar thermal and hydrogen fuel cell heating do not perform in the way that consumers with boilers are used to. These technologies usually generate steady low temperature heat rather than heating with controllable timing and temperature. They also work better in well insulated buildings. District Heating Networks also face some consumer scepticism, with concerns that they limit consumer choice.

Hydrogen Technologies

Hydrogen can be used to generate heat by burning it in a boiler or using it in a fuel cell, which generates both electricity and heat. In either case there are no direct GHG emissions. However, the carbon footprint of hydrogen heating technologies can vary greatly depending upon the source of hydrogen. Hydrogen can be produced: from natural gas, Coal, or biomass resulting in direct carbon emissions, which could be captured and stored underground using carbon capture and storage (CCS).

Technological Constraints and Advantages

There are a variety of technological constraints that may affect or limit the use of different technologies.

The widespread use of biomass may be limited by the availability of sustainable biomass.

Biomass burning can also affect air quality, by producing nitrous oxide and particulates, such as soot.

If hydrogen was injected into UK gas pipes and made up more than a small amount of the subsequent gas, then all gas-using appliances would need to be adapted.

Some new technologies require more space than existing technologies. This can create difficulties for smaller urban properties and in properties with strict planning rules.

Geothermal is limited to areas with suitable geology.

Conversely, District Heating Networks (DHNs) have benefits beyond being low carbon. They can take advantage of the benefits of more than one heat source at one location. They also allow heat sources to be changed (to a low-carbon heat source) with little disruption to consumers once the District Heating Networks is initially fitted.

Approaches to Reducing Heat Emissions Models of how 'best' to decarbonise heat have differing priorities: minimising cost, maximising emissions cuts or satisfying consumer preferences.

The models vary greatly but suggest that from 2030,

- a significant proportion of domestic heating should come from electrification using heat pumps (including hybrid heat pumps) and electric heaters.
- using bio-sourced gases or hydrogen in the gas grid and an increase in district heat networks in the industrial sector. Carbon Capture Storage (CCS) is a key technology to decarbonise high temperature heat; electrification plays a role in some industries.
- low-carbon heating should be introduced in parallel with the decarbonisation of electricity and a reduction in heat demand from increased energy efficiency.

It is widely agreed that this will be difficult to achieve and is likely to require an increase in policy intervention.
Policies to encourage the take-up of low carbon heating will have to be considered by the governments and other institutions responsible.